



Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service



ETH zürich



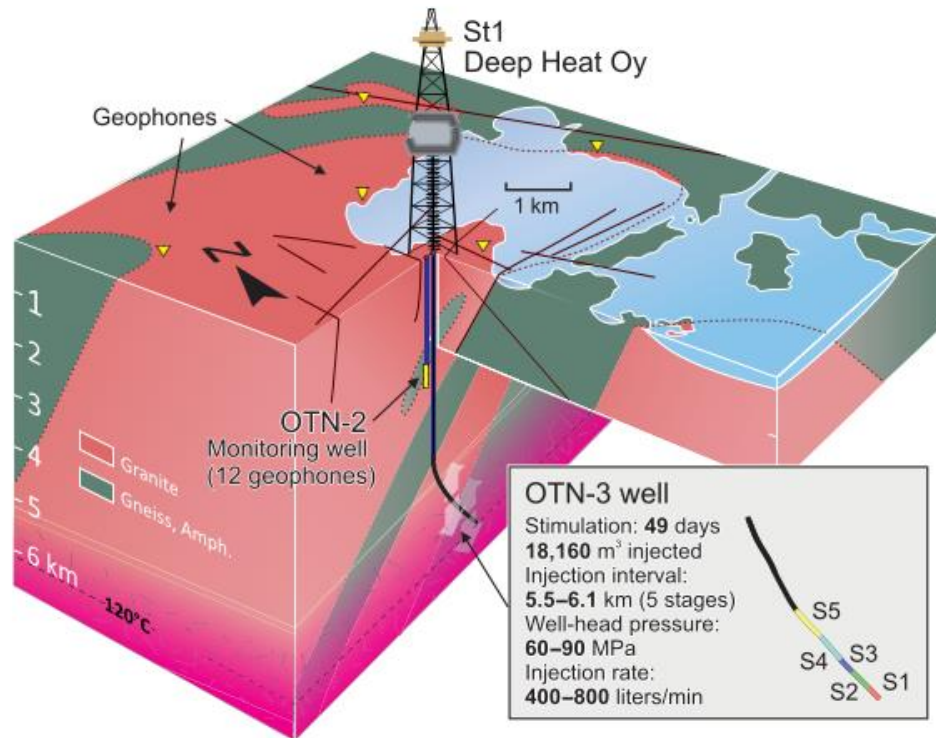
An Adaptive Traffic Light System for Geothermal Operations

Vanille A. Ritz

Moment d'Échanges Scientifiques et
Sympathiques Autour des GEoscienceS

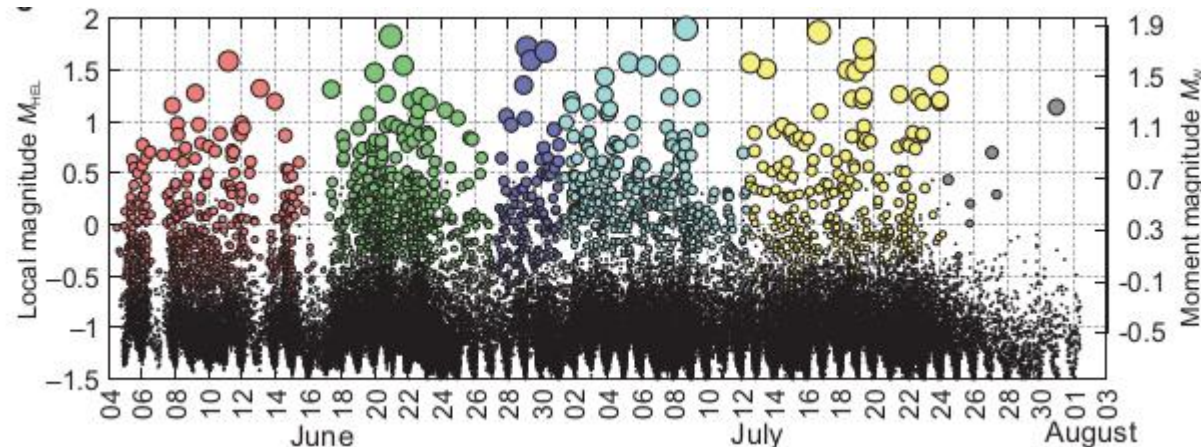


EGS & controlling induced seismicity: sometimes successful



- Helsinki summer 2018
- 6.1 km deep geothermal well
- 18,160 m³ of fresh water pumped over 49 days
- 24 borehole seismometers network
- $M_{\text{red_light}} 2.0$ for TLS
- $M_{\text{max,obs}} 1.9 (M_L)$
- 8412 events recorded

Kwiatek et al., 2019

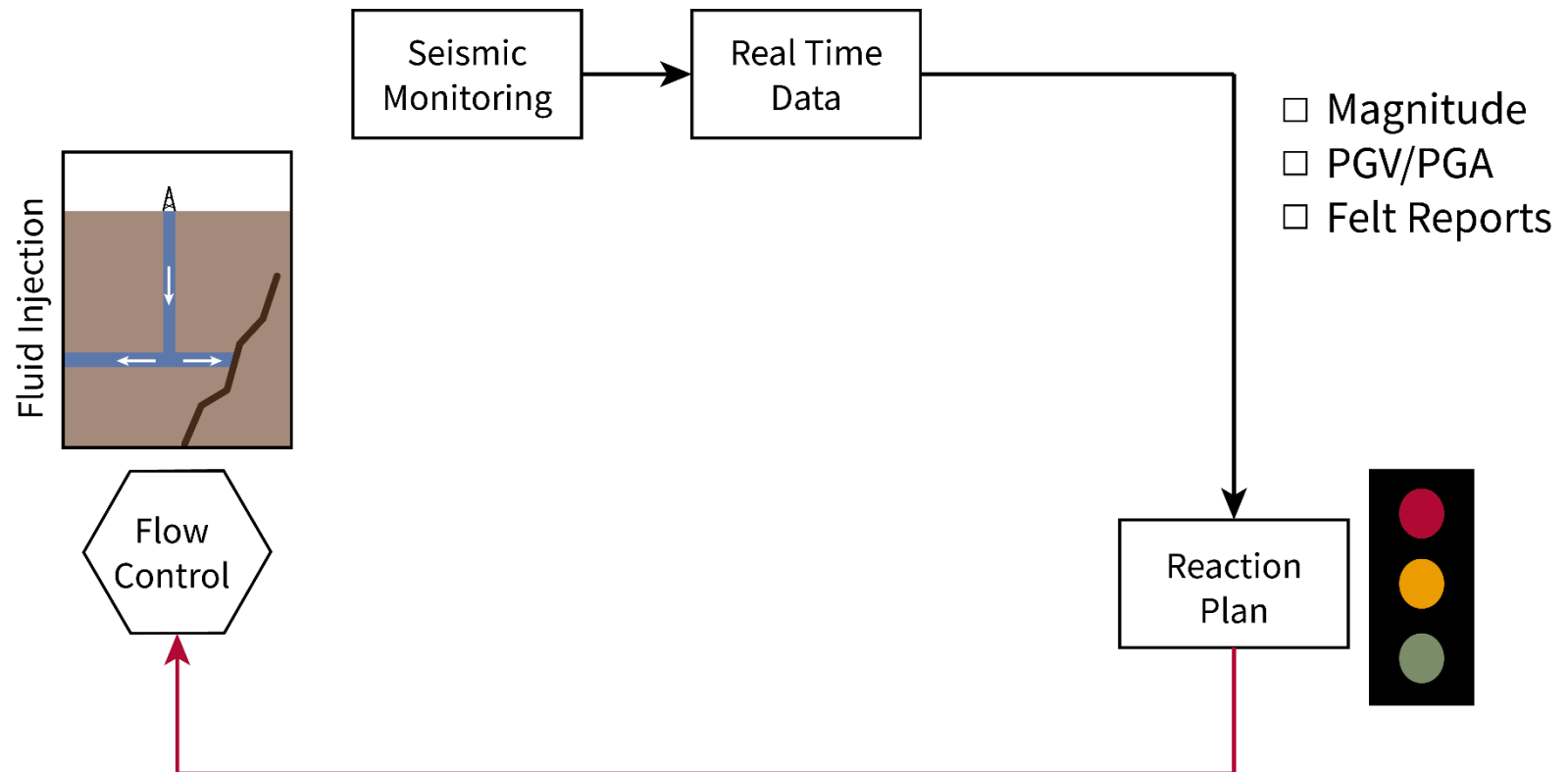


Traffic Light System

Simple, useful – but not very smart:

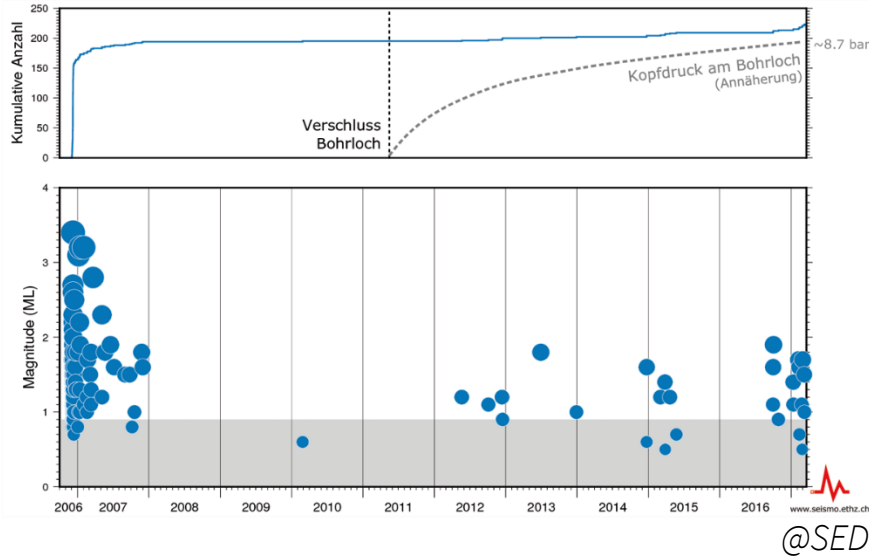
The weather analogue: A TLS means that you take an umbrella if you see cloud emerging.

Useful for the short term & simple and robust. But not robust against surprises nor for longer forecast horizons.

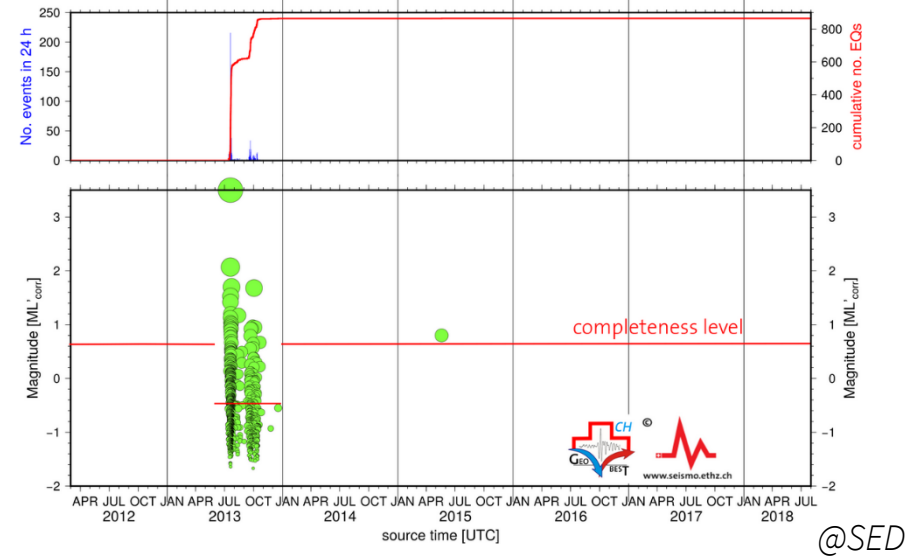


EGS & controlling induced seismicity: sometimes less successful...

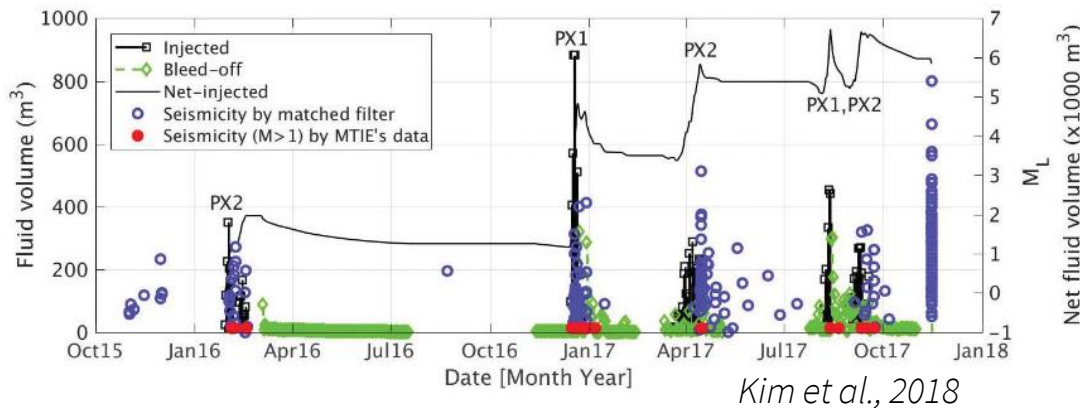
Basel 2006



St Gallen 2013



Pohang 2017



Beyond the Traffic Light System

Beyond cloud viewing

- If you plan your next weekend trip, you will check a forecast.
- A forecast will take a lot of data, and various models to give you the best estimate of what will happen in the next days...
- And you would expect that:
 - Models are tested, validated.
 - As new data arrives, models are updated.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Office fédéral de météorologie et de climatologie
MétéoSuisse

Actualité | Météo | Climat | Valeurs mesurées | Système de mesure et de prévision | Recherche et collaboration | Service et publications | Portrait

Aperçu de la météo

Bulletin météo

Dangers

Bulletin des dangers naturels

Mes prévisions

Précipitations

Température

Vent

Nébulosité

Index UV

Prévisions polliniques

Aujourd'hui | jeudi | **vendredi** | samedi | dimanche | lundi | Aperçu à 6 jours

0 - 6 | 6 - 12 | 12 - 18 | 18 - 24

Heure

Prévisions pour la Suisse
vendredi, 28 juin 2019

Dernière mise à jour des prévisions: 26.06.2019, 21:38

Prévisions locales
Zurich
vendredi, 28 juin 2019

NPA ou Ville

Sélectionner un lieu

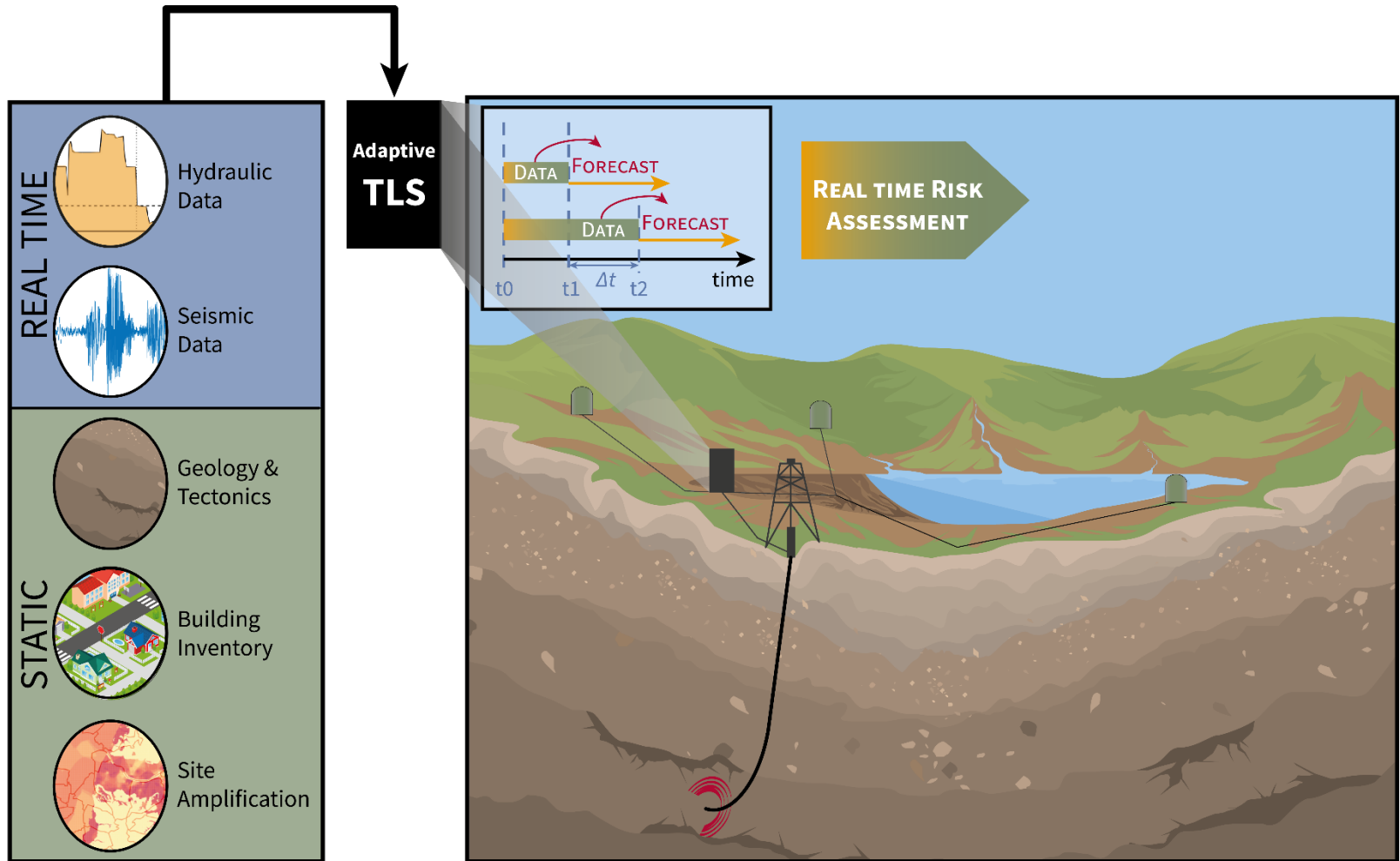
Température en °C

Précipitations en mm/h

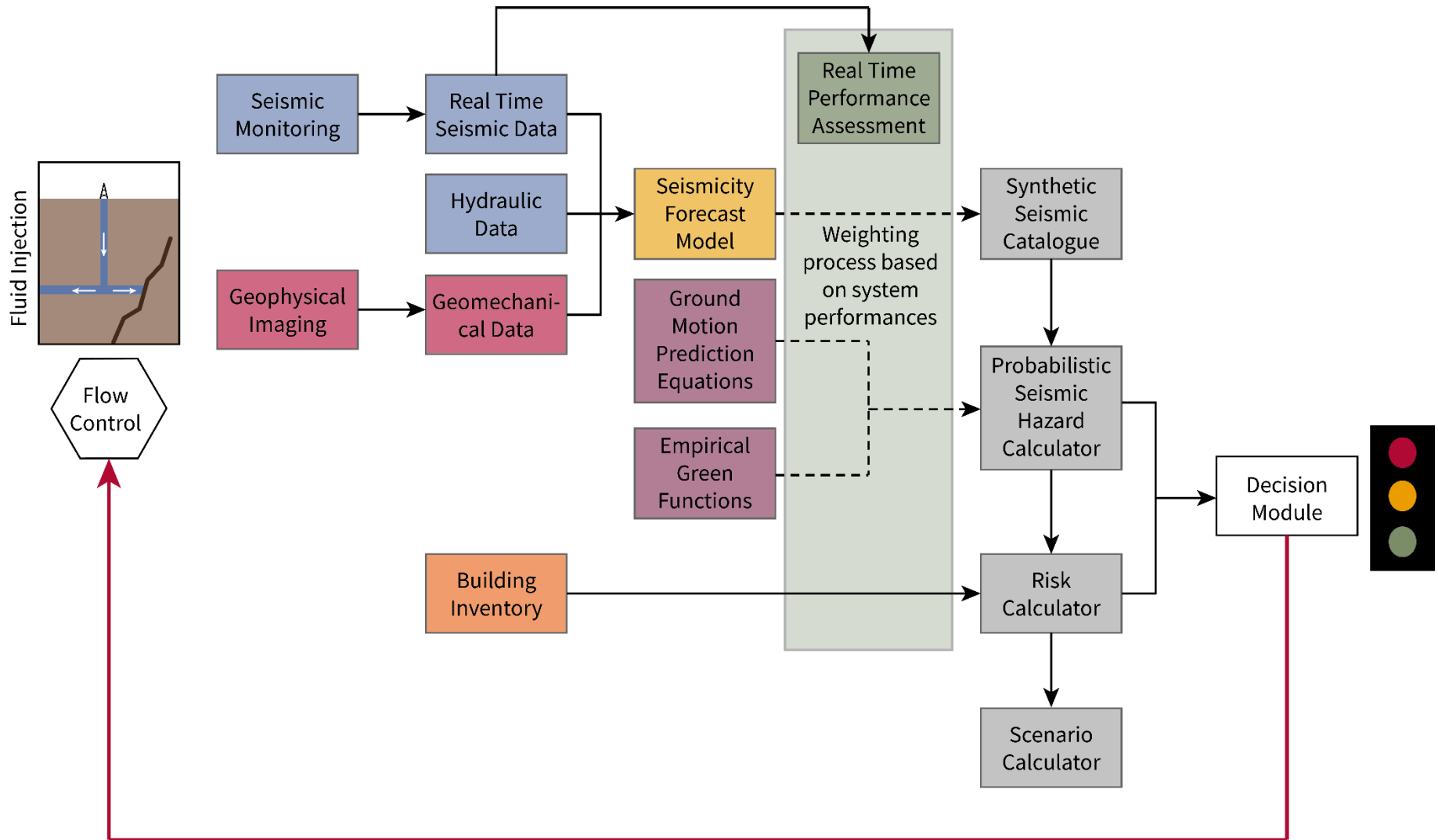
00:00 | 03:00 | 06:00 | 09:00 | 12:00 | 15:00 | 18:00 | 21:00

vendredi

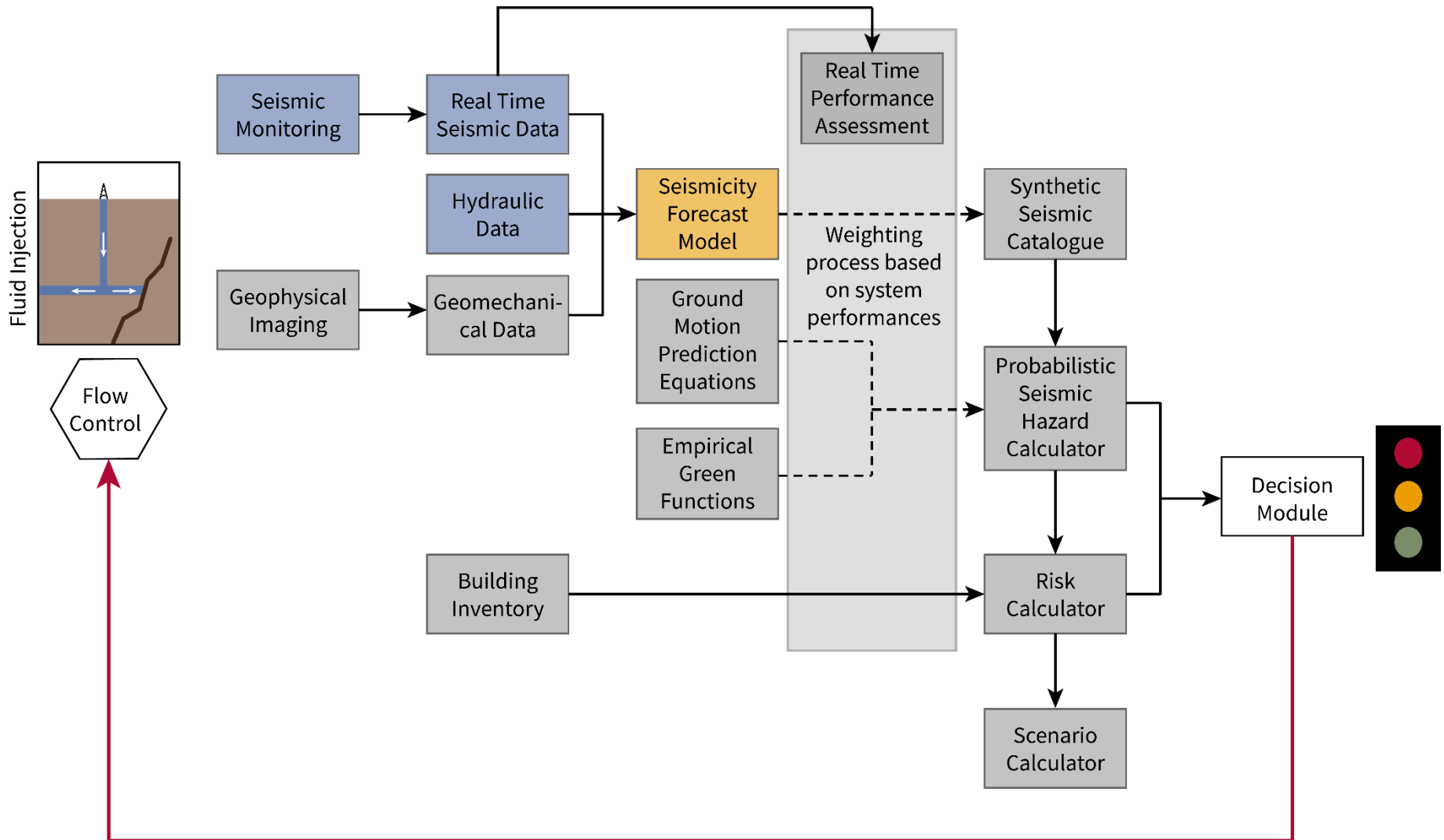
Adaptive Traffic Light System: Monitoring in REAL-TIME



Adaptive Traffic Light System

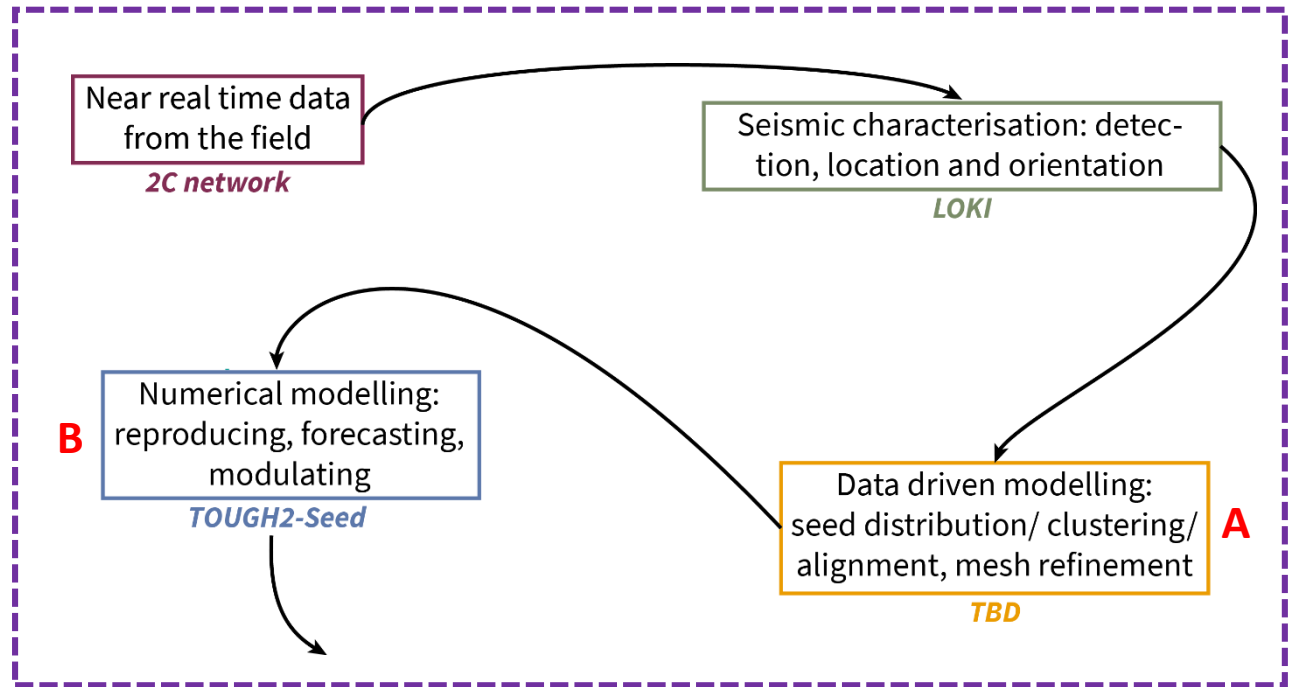


Adaptive Traffic Light System

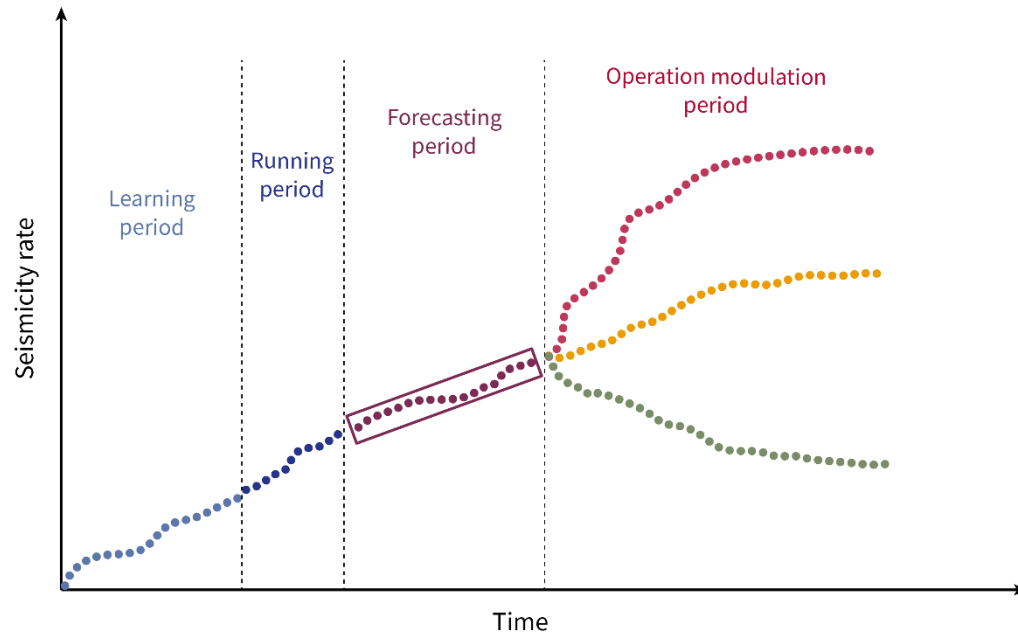


Adapted from Grigoli et al., 2017

Adaptive Traffic Light System: Forecasting



part of RT-RAMSIS

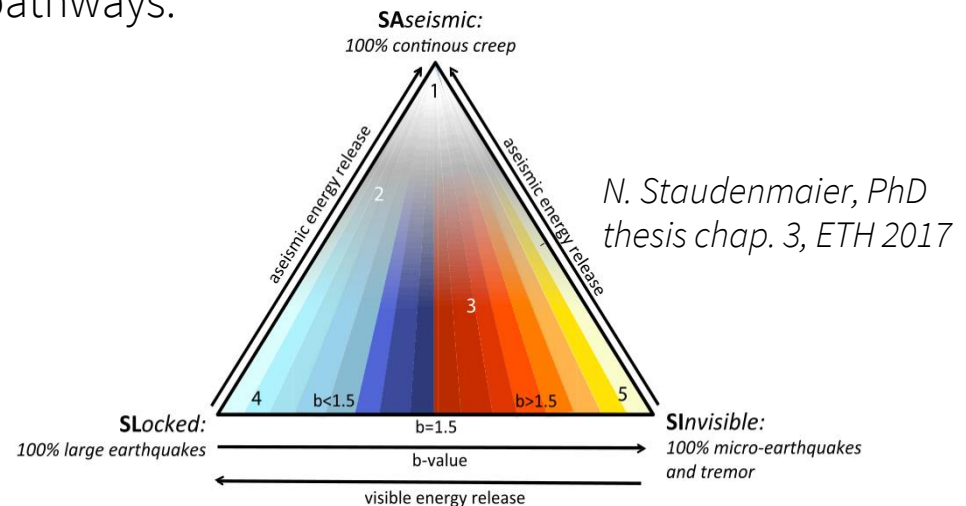
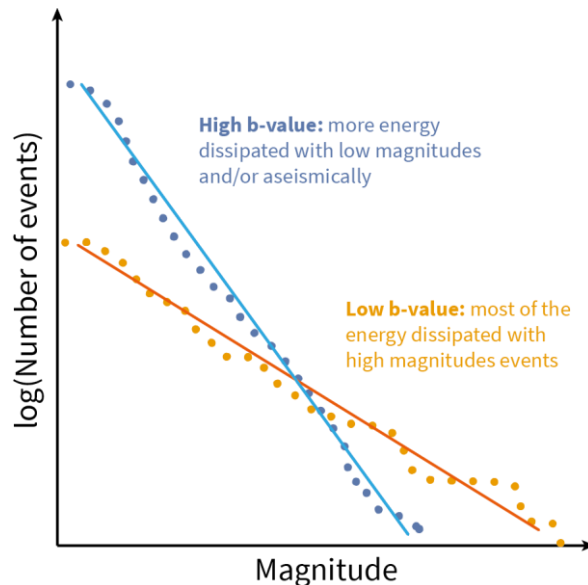


ATLS: geomechanical modelling

- A:** Using seismological data to improve the modelling as the operations go
 - focal mechanisms
 - clustering and/or alignments of events

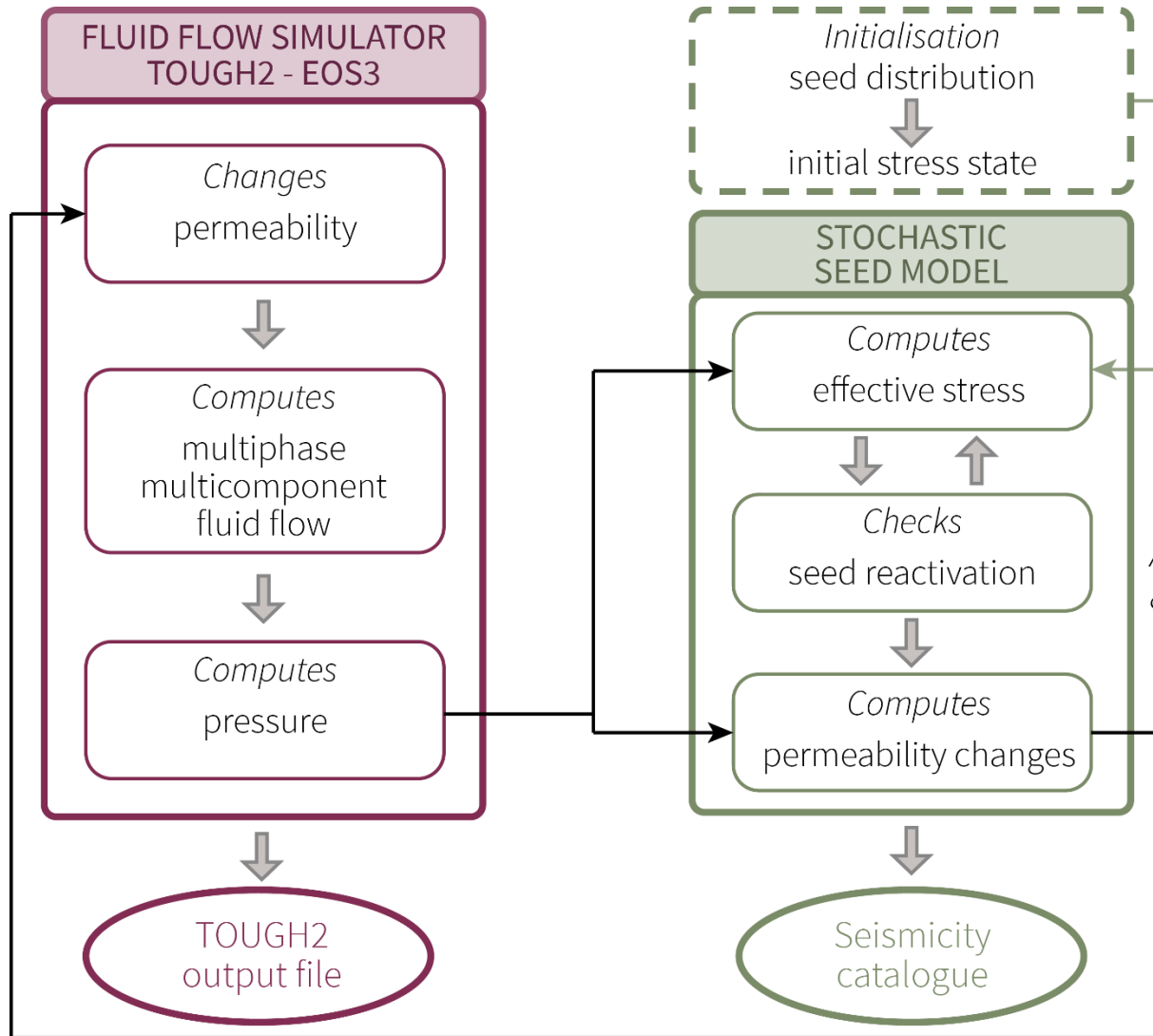
- B:** Forecasting based on current injection plan & alternative injection scenarii
 - balance risk/efficiency
 - b-value in time

→towards guiding operations in terms of injection to reach high b-values and aseismically created pathways.



TOUGH2-Seed

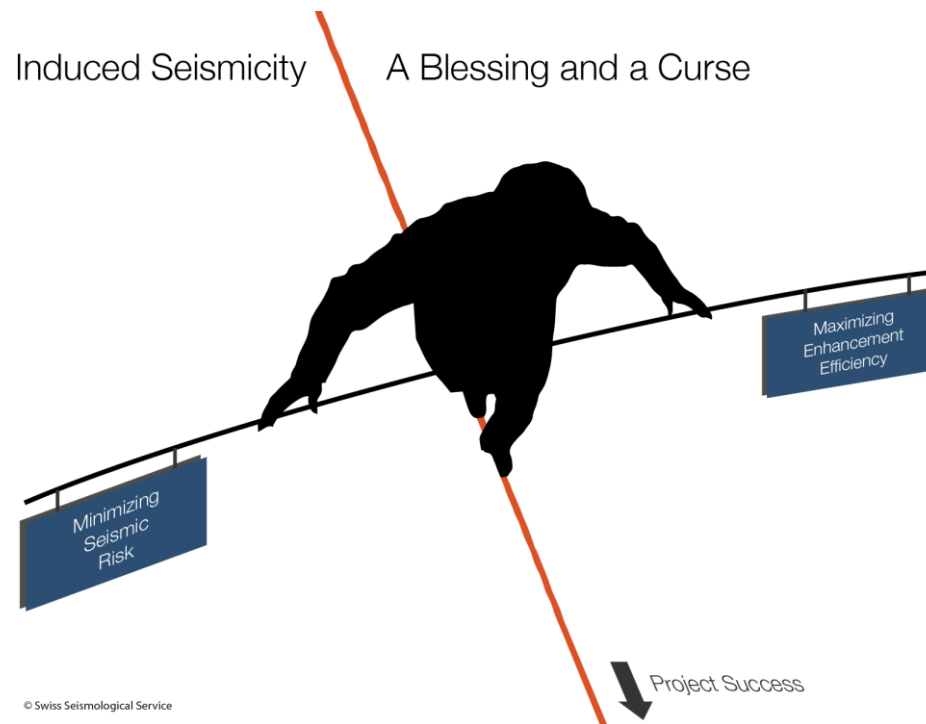
A coupled hybrid hydro-geomechanical model



Adapted from Rinaldi & Nespola, 2017

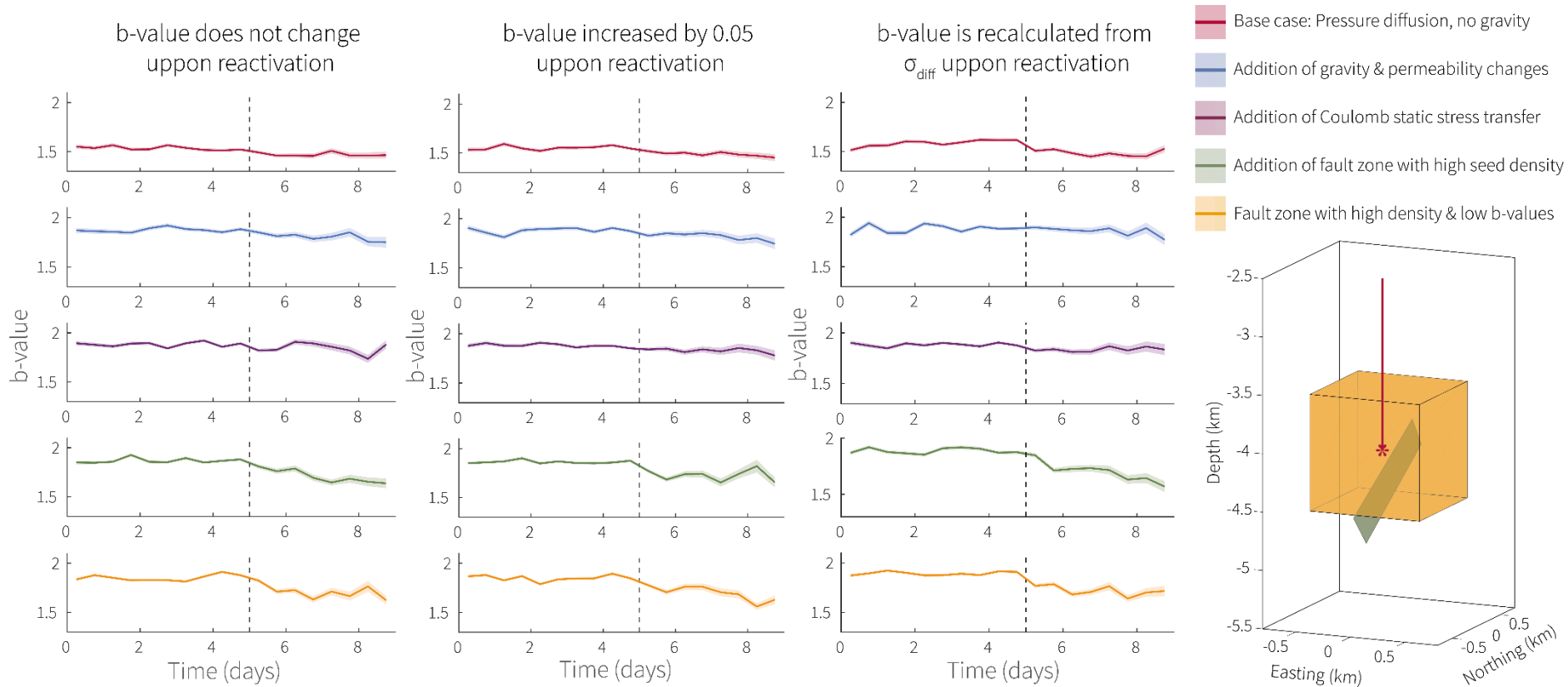
Current work

- TOUGH2-Seed model complexity tests
- B-value evolution in time and space
 - From basic model (Goertz-Allmann & Wiemer 2013) to full T2S
- Injection strategies: determining the 'best' efficiency/risk ratio
 - Stimulation factor



Current work

b-value evolution in time and space – Increasing Model Complexity



Ritz et al. 2019 (in prep)

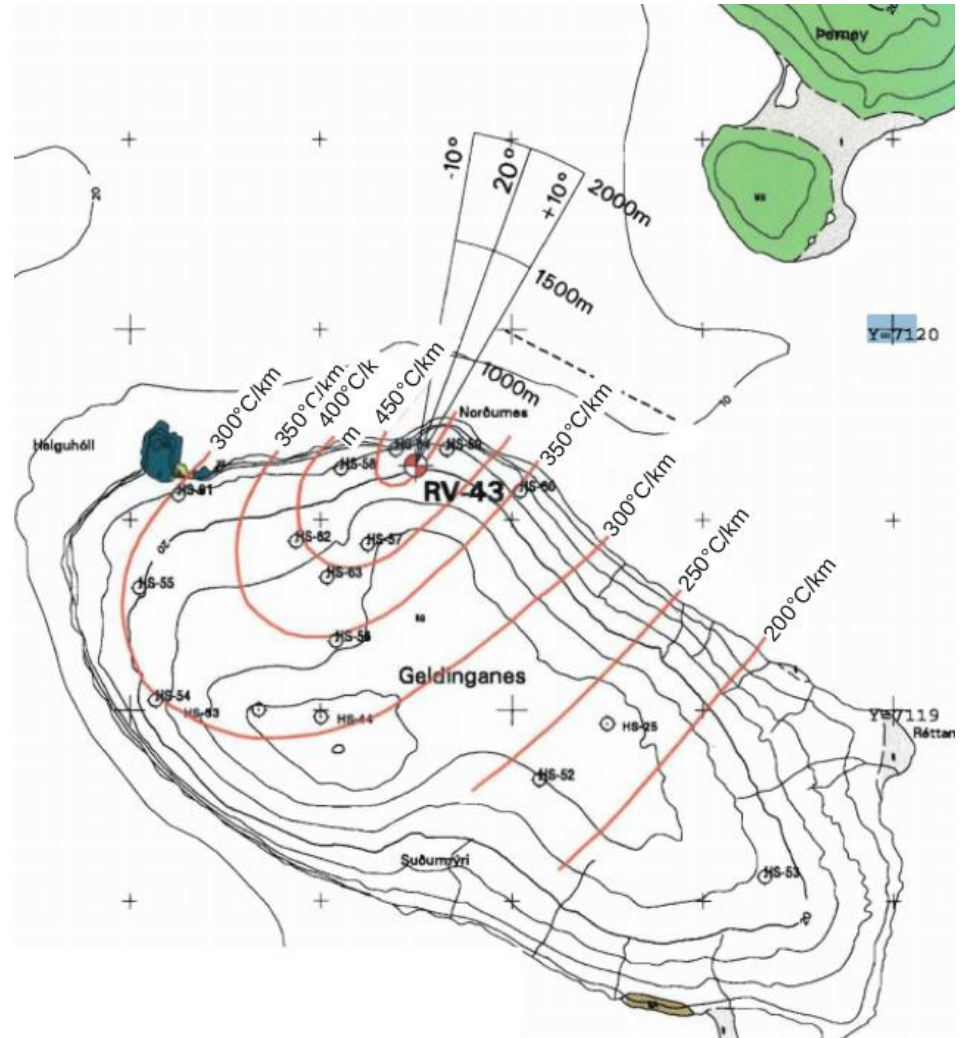
ATLS applications this summer: first demonstration

Geldinganes peninsula, Iceland

District heating for Reykjavík



ATLS applications this summer: first demonstration



Future of ATLS

- Integration of more complex models
 - THM models planned
 - Geochemistry to go to THMC?
- To be applied in other EGS test sites
- Use in everyday operations of hydrothermal reservoirs
 - Hengill (Hellisheiði and Nesjavellir)
- Your ideas for further developments and test sites are very welcome

Thank you for your attention !